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Survey of Slag Utilization in India

Draft report

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List of Acronyms

SAIL	Steel Authority of India Limited
TISCO	Tata Iron and Steel Company
IISCO	Indian Iron and Steel Company
VSP	Visakhapatnam Steel Plant
GNP	Gross national product
BSF	Blast furnace slag
HM	Hot metal
SMS	Steel melting shop
OH	Open hearth
BOF	Basic oxygen furnace
HRC	HR coil
SK	Skelp
SH	Sheet
CRC	CR coil
FY	Full Year (Financial year-1st April to 31st March)
HF	Half Year (1st April to September end)

Introduction

Slag is a by product of the manufacture of iron and steel. The volumes produced are correlated with the quality of the inputs used in the manufacture of iron and steel and the efficiency of the conversion process. The domestic production of steel has grown from a level of 10 million tons in 1985-86 to a level of 17.8 million tons in 1994-95 at a growth rate of 5.9% per annum. The country is largely self sufficient in iron and steel and imports have varied between 1.5 to 2 million tons per year over the last five years. Demand for finished steel is projected to increase to a level of 31 million tons by 2001-02. It is estimated that the production of slag varies between 0.3 to 0.5 tons per ton of 'hot metal' or 'pig iron' produced. The current production of all varieties of slag is estimated at between 6 to 8 million tons per year.

2. In India, though the marketable and usable attributes of slag are recognized, there is insufficient effort in increasing the physical utilization of slag. Consequently unlike the developed economies where reutilization levels have reached close to 100%, the bulk of the slag production in India is either dumped or utilized in low preference options like road building and railway ballast. The most widely adopted utilization is in the manufacture of cement. However, the process of granulation and subsequent transportation to the consumers site present barriers. Consequently the utilization of slag in cement manufacture does not exceed 5 million tons per annum.

3. There is no concrete plan at the level of the Government of India to increase the utilization of slag. However, there is wide spread recognition, in industry as well as within the Government of India, that this is a neglected and environmentally sensitive area where additional efforts are required. While the steel industry in India has been dominated by the public sector no further expansion of capacity is envisaged in the public sector. The last public sector steel plant of the Vishakhapatnam Steel Plant was commissioned in 1992 and is currently being established but will add another 3 million tons is expected to be met from the installation of private capacity and imports. The private sector has always played a crucial role in steel manufacture in India. In 1993-94 the

private sector contributed 48% of the total domestic production of finished steel of 15 million tons. The incremental capacity addition required to fill the demand supply gap over the next decade is also expected to be added in the private sector. Consequently its share in total production of finished steel is expected to increase to around 60% by 2001-02. Major initiatives for the better utilization of slag will therefore also need to be taken by the private sector where the bulk of the production capacity will lie by 2001-02.

4. Liberalization of the economy with the attendant emphasis on enhanced efficiency in the use of resources is also expected to exert a push towards more efficient and profitable waste recycling. Similarly the need to adhere to stricter environmental standards will also push industry towards more efficient waste and by product management. The major producers have already recognized the need to move in this direction. The response time of he smaller producers who contribute around one fourth of the total production of steel is expected to be longer and will need to be induced through a policy package of fiscal incentives and environmental disincentives.

Scope of the survey

This survey aims at a empirical, time series data based analysis of the potential for the utilization of slag in India. The following are the main areas :

- Review of the steel industry in India since 1985-86 along with a profile of the major steel manufacturers in India.
- Presentation of statistics on the production of slag in India over the last five years.
- Identification of the major uses of slag.
- Identification of existing barriers in increasing the utilization of slag.
- Outline of the likely initiatives towards increasing the utilization of slag.

Published data on the production and use of slag is not available. Consequently, this paper has relied on informal, secondary sources for obtaining this information. Similarly, production data for the year 1994-95 is not available for the steel industry for which this paper has relied upon feed back from plant level sources. Valuable information has also been acquired through informal interviews with the relevant persons in the major steel manufacturers, industry associations and the Government of India.

Profile of steel industry

Status of steel production

Like other infrastructure industries in India, the steel industry is dominated by the public sector (defined as corporations incorporated under the Companies Act but with the majority share holding of the Government of India. The Steel Authority of India (SAIL) is the largest public sector producer of steel and contributes 46% of the total domestic steel production. The largest private sector manufacturer is the Tata Iron and Steel Company (TISCO), which contributes 6% of the total production of steel. There are 7 large plants, 170 mini plants and over 5000 small foundries. Appendix 1 provides a map of India indicating the location of major steel plants. The production of pig iron and finished steel in India from 1995-86 to 1993-94 has gone up by an annual growth rate of 7.23% and 5.3% respectively. Appendices 2 & 3 provide the production data for iron and steel.

Profiles of major steel makers

Public Sector Steel Manufacturers

2. The Steel Authority of India Limited (SAIL) is a government undertaking and the largest producer of steel in India, with steel plants at Bhilai, Durgapur, Rourkela, Bokaro, Burnpur and Salem. The management of Indian Iron and Steel Corporation of India (IISCO) was taken over by the Government of India on 14 July 1976. It is now a wholly owned subsidiary of SAIL. The authorized capital of SAIL was Rupees 50 billion and the paid-up capital as on 31 March 1992 was Rupees 101.5 billion (excluding IISCO). Visakhapatnam Steel Project is not only the first integrated steel plant in the shore area but also the first plant in the southern part of the country. Many modern technological features have been included in this project like a seven-meter tall coke oven battery, high capacity blast furnace and continuous casting facilities. It is expected that automation and computerization of process control will not only improve the quality and efficiency of production but will substantially reduce the

employee cost. Its anticipated productivity of 230 tons per man year would be much higher existing productivity levels. The total capacity of VSP is three million tons of crude steel per annum. During 1992-93, VSP produced 1.981 million tons of hot metal, 1.052 million tons of crude steel, 0.879 million tons of salable steel and 0.914 million tons of pig iron.

Private Sector Steel Manufacturers

3. A list of the major private sector manufacturers is provided in Appendix 6 while Appendix 7 provides a list of the smaller private sector manufacturers. Out of a total sale of the large manufacturers in 1994 of Rs 17 billion TISCO had the largest share of 22% amongst the large private sector manufacturers. Six other large manufacturers accounted for an additional 17% of sale while the remaining 61% was on account of SAIL. In the same year the smaller manufacturers accounted for a sale of only Rs 2 billion.

Prospects for future steel production

4. The current available projection of domestic demand for finished steel is 27 million tons and 36 million tons for the year 1999-00 and 2004-05 respectively. The projection of demand of different steel products, finished steel and pig iron for the year 1994-95, 1999-2000 and 2004-05 is also presented in Appendix 6 along with the availability of various steel products for 1994-95. The trend rate of growth in steel demand of around 5.3% over the period 1985-86 to 1994-95 matches the growth of the gross national product (GNP) over this period at constant prices of 5.2%. Steel consumption has consequently displayed a unitary elasticity with respect to GNP growth. GNP growth over the period 1995-96 to 2001-02 is expected at an annual average rate of 6.5%. The estimates of steel demand by 2006-07 cited above conform to a unitary elasticity against a GNP growth per year of 6.5% till 2006-07.

Generation and Use of slag

Generation of slag

Slag is produced during the manufacturing of iron in a blast furnace due to the slagging constituents of the furnace (fluxes and coke ash). High ash coal is probably the most important reason for the comparatively higher generation of solid waste in Indian steel plants. Till recently most of the mineral and ore extraction industry has been in the public sector with rationing and allocation of production and concurrent import controls. Consequently steel plants have till now had little control over the quality of inputs. With the partial liberalization of the ores and mineral extraction industry in India and the decontrol of allocation of production it is expected that quality standardization of inputs based on market determined prices would increasingly be possible. However downstream utilization of wastes by recycling and downstream processing of the solid waste generated in the iron and steel making remains a underutilized option.

2. It is estimated that the amount of blast furnace slag produced in India is on average 300-500 kg per ton of hot metal depending on the quality of ore and other raw materials used. Blast Furnace Slag (BFS) is the single largest component, accounting for nearly 50 per cent, of the total solid wastes arising from the steel plants. The total quantity of BF slag generated in SAIL plants during 1993-94 and 1994-95 has been about 4.19 and 4.58 million tons respectively, for a total hot metal production of about 10.87 and 11.69 million tons. The generation of total BF slag for SAIL plants is estimated to go upto 5.13 and 6.06 million ton by 1995 and 2000 respectively. The total generation of slag by 2000 in India is estimated at 10 million tons on a business as usual scenario without factoring in efficiency improvements in waste generation. The generation rate, total generation and hot metal output of BF slag from four major integrated steel plants for the period 1988/92 is given in Table 4.1 below.

Table 4.1 Generation of Blast Furnace Slag (BFS) in four integrated steel plants

Million Tons

	Year ending March 31	*1989*	*1990*	*1991*	*1992*	*1993*
Bokaro	Hot metal output (HM)	3.22	3.20	3.27	3.67	3.86
	Slag generation rate (kg/ton of HM)	476	438	431	427	439
	Total slag generation	1.53	1.40	1.41	1.56	1.69
Durgapur	Hot metal output (HM)	1.09	1.06	0.97	0.94	0.72
	Slag generation rate (kg/ton of HM)	504	491	488	519	570
	Total slag generation	0.55	0.52	0.47	0.48	0.41
Rourkela	Hot metal output	1.25	1.26	1.32	1.32	1.29
	Slag generation rate (kg/ton of HM)	396	367	404	354	379
	Total slag generation	0.49	0.46	0.53	0.47	0.49
TISCO	Hot metal output	2.24	2.27	2.32	2.40	2.44
	Slag generation rate (kg/ton of HM)	326	347	342	337	355
	Total slag generation	0.73	0.79	0.79	0.81	0.87

Source: SAIL Statistics 1994, Steel Scenario, 1992

3. Slag generation data for the following two steel plants is available only for 1988-89 and is provided in Table 4.2 below.

Table 4.3 Generation of slag in two steel plants in 1988-89

million tons

	Bhilai	***IISCO***
Hot metal output (HM)	3.3	0.77
Slag generation rate (kg/ton of HM)	433	754
Total slag generation	1.43	0.58

Source: Encare 1991

As is evident from the data there is considerable variation in the production rate of slag. Rourkela which is a SAIL plant and TISCO are the most efficient in having lower rates than the others while IISCO Durgapur steel plant a SAIL unit are the most inefficient.

4. Steel Melting Shop (SMS) slag is the second largest component, accounting for nearly 20 per cent, of the total solid wastes generated by steel plants. The total quantity of SMS slag generated in SAIL plants during 1993-94 has been estimated at about 1.86 million tons. The generation of SMS slag by 2000 is unlikely to exceed 4 million tons per year. Table 4.3 shows the generation of SMS slag during 1988-89 in five Indian steel plants.

Table 4.2 Generation of SMS slag during 1988-89 in Indian steel plants

million tons

Details	Bhilai	Bokaro	Durgapur	Rourkela	IISCO	TISCO	Total
Open Hearth	0.33	-	0.29	0.03	0.17	0.19	1.00
Basic oxygen fur.	0.29	0.57	-	0.30	-	0.25	1.40
Total SMS slag	0.62	0.57	0.29	0.33	0.17	0.44	2.40

Source: Encare, 1991

The use of sinter in the blast furnace of Indian steel plants has increased. The result has been a dramatic reduction in blast furnace slag rate at all the plants. The sinter rate and its consequent reduction of slag rate in three of the SAIL plants are shown in Table 4.4.

Table 4.4 Sinter and slag rates for different steel plants

Year ending March 31	1986	1987	1988	1989	1990	
Rourkela	Sinter rate (kg/ton hot metal)	728	787	826	886	953
	Slag rate (kg/ton hot metal)	451	442	396	367	404
Bhilai	Sinter rate (kg/ton hot metal)	1037	1021	910	912	932
	Slag rate (kg/ton hot metal)	470	487	433	406	402
Bokaro	Sinter rate (kg/ton hot metal)	1058	1032	1020	1044	1146
	Slag rate (kg/ton hot metal)	706	679	476	438	431

Source: Steel Scenario, SAIL, 1992.

Current uses of slag

Use of slag by industry

5. 30-60 % of blast furnace slag is presently being granulated in most of the steel plants in India depending upon the market requirements in the area. Granulated slag is mainly used in the manufacture of cement, construction of highways and as aggregate for concrete products and in some cases for soil conditioning to neutralize soil acids. The total production of slag cement in India was of the order of 5.8 Million tons (10 % of the total cement production) in 1994-95 and is expected to go up to 7.3 Million tons (11 % of the total cement production) in 1995-96. Table 4.5 below provides estimates of the volume and share of granulation done by different steel plants of their BF slag production.

Table 4.5 Granulation of slag in 1988-89

million tons

	Bhilai	*Bokaro*	*Durgapur*	*Rourkela*	*IISCO*	*TISCO*	*Total*
BF slag generation	1.43	1.53	0.55	0.5	0.58	0.73	5.32
Granulation	1.15	0.3	nil	0.2	0.36	0.17	2.78
% granulated	80%	20%	0%	40%	62%	23%	52%

Source : Encare 1991

The ratio of granulation varies significantly between the steel plants depending on the arrangements made at the plant level for the sale of granulated slag. In the case of Bokaro some public sector cement units have preempted the sale of slag through long term purchase contracts but have not lifted slag in the contracted quantities resulting in a lower rate of granulation.

6. Steel making shop slag has not found any use and being dumped in and around the steel plants.

Use of slag by major steel makers

7. Granulated slag is being produced at SAIL steel plants since the early 1980s. However the yield is only about 60% of the rated efficiency of granulation when granulation is done at slag dump yards located far away from the main casting house. The total generation recycled of BF and SMS slag,

and sale of granulated slag in SAIL plants during the period 1992/95 is given in Table 4.6.

Table 4.6 Management of slag in SAIL plants **million tons**

Year ending March 31	1992	1993	1994	1995
Generation of BF slag	-	-	4.19	4.58
Generation of SMS slag	-	-	1 86	1.90
Recycled BF slag	0.14	0.11	0.13	-
Recycled SMS slag	0.27	0.36	0.31	-
Sale of granulated slag	1.83	1.68	1.56	1.85

Source: Personal communication.

As is evident the bulk of the BF slag is being sold as granulated slag and only marginal quantities are being reused inside the plants. The bulk of the SMS slag is being dumped in and around the steel plants.

8. Details of the current generation and management of slag in the Rourkela, Durgapur and Bokaro steel plant of SAIL have been given in Table 4.7, 4.8 and 4.9 below.

Table 4.7 Slag management-Rourkela Steel Plant for 1994-95

million tons

	Generation	Recycled		Sold		Dumped
		Quantity	Mode	Quantity	Use	
Air cooled BF slag	0.22	0.03	Road making	-	-	0.19
Granulated BF slag	2.22	-	-	0.21	Cement making	-
SMS- OH slag	0.07	-	-	-	-	0.07
SMS - BOF slag	0.19	0.05	Road making Rail ballast	-	-	0.14

BF - Blast Furnace , SMS - Steel Melting Shop
BOF - Basic Oxygen Furnace OH - Open Hearth

Source: CPCB, Delhi (personal communication)

Table 4.8 Slag management in Durgapur steel plant

million tons

Item	**Generation**	**Sold**	**Utilized**	**Dumped**
BF slag	**0.66**	**0.36**	-	**0.3**
SMS slag	**0.17**	-	-	**0.17**

Source: **Steel Scenario Vol 1/Q4, 1992.**

Table 4.9 Slag management in Bokaro Steel plant

million tons

Year	Liquid slag produced	Granulated slag	% of slag granulation
1988-89	1.533	0.361	24
1989-90	1.403	0.305	22
1990-91	1.409	0.204	15

9. The Tata Iron and Steel Company has currently brought down the slag rate to 318 Kg per ton of hot metal by improving raw material quality and also by introducing computerized process controls. Stamp charging techniques have also been adopted to produce better coke quality from Indian coal which has improved the blast furnace productivity and simultaneously reduced slag generation. At present 41% of the total blast furnace slag is being used for the production of slag cement. TISCO has set up a cement factory of capacity 1.75 million tons to utilize granulated slag internally. In contrast only 22% of SMS slag is being reused, out of which 6% is used in sintering whereas the rest 16% is being sent to waste recycling plant to recover the metallic contents.

Barriers to increasing the utilization of slag

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Technology Development

Steel industries in India are granulating the blast furnace slag for use by cement industry and construction of highway. However the following barriers restrict increase in the utilization:

- Slag granulation plant are located far away from the blast furnaces. Some times there is a complete rejection of cold slag due to loss of temperature during transportation.
- Rejection of the last 20% of slag due to concentration of metal in the lower portion of the ladle.
- Shortage of equipment like slag ladles and transportation facilities.

2. The BF slag which may not be used in granulated form, may be air cooled to produce lump (crystallized) slag, and may be used as aggregates. This aggregate is quite useful for all purposes for which stone aggregate is used and in some respect is even better than crushed natural aggregate. It is reported that even slag "dumped" earlier is being reclaimed for this purpose. Therefore, it is worthwhile in India to consider systematic air cooling of the excess (after granulation) BF slag and to set up facilities for crushing and sizing of this material. The crushing and screening operation may be conveniently combined with processing of melt-shop slag, including recovery of iron shots.

3. It may not be convenient for the steel plants to manufacture specialized items like light weight concrete, slag concrete masonry, slag wool, etc. Instead the steel plant authorities may consider other agencies interested in setting up of plants to make such products, and encourage the addition of such facilities by providing consistency in the quality BF slag as feed material to manufacturing units. SMS slags from Indian plants are being dumped so far. Therefore, efforts are needed to minimize dumping of SMS slags. This can be achieved by in-plant recycling to the extent possible and by conversion to construction material or use in agriculture, green belt development, as top soil at mine-fill sites . Prospects for these alternative uses are outlined separately in the following paragraphs:

4. SMS slags contain two valuable constituents namely iron and flux. The in-plant recycling of SMS slag can be feed material to the sinter plants and to the blast furnaces. Recycling in the SMS itself can utilize the flux component only. However, SMS slag is practically the only outlet for phosphorus in hot metal and hence the slag cannot be recycled fully. This is especially important in the Indian context due to high phosphorus content (over 0.2 per cent) of hot metal.

5. SMS slags are as rail road ballast in bituminous concrete, as well as in normal concrete. Air cooled BOF slag is suitable as a construction material and is even better to natural stone aggregates in some respects. However, these applications require sufficient volumetric stability, which can be improved to some extent by allowing the slag to mature as moist stock. Based on experience so far, the general recommendation is that BOF slag may be not used as aggregate for rigid bound mixtures such as crushed stone stabilized with cement, lean concrete and pozzolanic concrete. The material can be used in bituminous mixtures for underlayers, or in sub-bases or in road bases (unbound crushed stone). The steel plants may consider encouraging constructional use of SMS slag to the maximum extent instead of dumping. The slag will have to be air cooled and matured over a period which is to be determined by trials. Thereafter the lumps will have to be crushed and sized and iron content recovered. The processing of SMS slag can be combined with production of aggregate out of BF slag. The plant can also convert a portion of the BOF slag to sizes suitable for recycling through sinter plant or blast furnace, after the procedure for recycling is established.

6. SMS slags have a limited application in agriculture and greenery development. Some types of slags can be useful as fertilizer due to high P_2O_5 content. Also, lime and magnesia contents of the slag can be useful in neutralizing acidic soils and the slag can be used as soil stabilizer. However, P_2O_5 contents of BOF slags from Indian plants are of the order of 2.5 per cent being too low to be useful as a fertilizer. The slag can still be useful for neutralizing acidic soils and for stabilizing soil. These uses will require studies by agronomists and may be taken up by steel plants together with relevant Government agencies.

Stability of the quality of slag

7. The quality of the slag does not fluctuate much both for BF and SMS slag. The chemical composition of BF and SMS slag has shown in Table 5.1 below

Table 5.1 Chemical composition of BF and SMS slag

Source	Chemical composition %
Blast Furnace Slag	CaO = 31 - 33 SiO_2 = 30 - 33 Al_2O_3 = 22 - 24 MgO = 9 - 12 F = 0.3-2.4 S = 1 - 2
Steel Making Shop slag	SiO_2 = 20.1 Fe_2O_3 = 3.6 FeO = 30 4 Al_2O_3 = 5.9 CaO = 20.2 P_2O_5 = 4.6 MnO = 7.0 MgO = 6.1

Source: Central Pollution Control Board, Govt. of India

Establishment of distribution routes for slag

8. Transportation of slag by rail which is the most economic method to move it in bulk will remain a problem due to insufficient capacity. The bulk of the granulated slag is currently sold to cement manufacturers. Out of the major steel plants, so far only TISCO has integrated forward and established a cement plant which will use the granulated slag produced by it. There are no major wholesellers trading in slag as of date. However it is conceivable that in the future as the steel industry gets progressively privatized two separate distribution channels may emerge: One would be the traditional direct sale to cement manufacturers. The second would be sale by steel plants to wholesellers who would in turn supply to manufacturers of specialized products.

Initiatives for increasing the Utilisation of slag

Government

A National Waste Management Committee had been set up by Ministry Environment and Forest, Government of India on in 1990 to advise the Government on all matters concerned with disposal and Utilisation of the waste of different industries. Slag generated from the steel plants has been identified as a major area of concern. The Central Board of Pollution Control of the Government of India has recommended the following initiatives for increasing the utilization of slag which are provided in Table 6.1.

Table 6.1 Recommended utilization/reuse/recycling of slag

Unit	Waste generated	Method for reduction/elimination/utilization
Blast furnace	BF Slag-	Manufacture of slag cement, super sulphated cement, metallurgical cement
	-	Non Portland cement
	-	Specialized cement, oilwell, colored cement, high early strength cement
	-	In refractory and in ceramic industry
	-	As a structural fill (air cooled slag)
	-	As aggregates in concrete
Steel melting shop	SMS slag	By adopting hot metal pre-refining slag can be reduced from a level of 200 - 250 kg/t to a level of 80 - 100 kg/t and the slag can be recycled via sintering process.
	-	Adoption of blast granulation system of slag and utilization of recovered product in SMS or sintering plant.
	-	Use as aggregate for road and building construction.
	-	Filling up for ditches/mines/collieries etc.
	-	Use as soil conditioner for acidic soils and also as soil nutrients.

Source: **CPCB Delhi, 1988.**

2. The Government of India has provided the following incentives for encouraging participation of the private sector in steel manufacture:

a) The New Industrial Policy, July 1991 has removed steel from the list of industries where compulsory licensing is required. On the basis of compliance with environmental requirements steel plants can now be established without the prior approval of the government.

b) The system of Government control over pricing and distribution was amended in 1992 to permit commercial autonomy to the producers. Producers are now free to decide the price and the volume of steel and steel products.

c) To encourage foreign investment in steel this industry is included in the list of high priority industries where automatic approval is available for equity investment upto 51% of the equity capital by a foreign investor and for foreign technology exchange contracts. Proposals for equity participation at ratios more than 51% are also considered by the Foreign Investment promotion Board set up in the Prime Ministers office.

d) Imports of raw materials and capital goods have also been made easier.

e) The restrictions on exports of steel have been removed and export related decisions left to be decided on commercial considerations alone.

The impact of liberalization of the steel industry started in 1991 has been very positive. Since July 1991 nearly 5 million tons of additional finished steel capacity is under installation in the private sector at an estimated investment of Rs. 84 billion (US $ 2.3 billion). Secondly, exports of steel and steel products have also grown and were around 2.2 million tons (finished steel and pig iron) in 1993-94 and are expected to increase to 3.5 million tons by 1996-97. The export level compares favorably with the import level of around 1 million tons in 1993-94 illustrating the self sufficiency of the country in steel.

Steel producers

3. Most of the major steel producers in India have taken the initiative for minimization of slag production by using sinter in blast furnace and the maximum Utilisation of slag. Steps are being taken for increasing the granulation capacity through installation of these facilities closer to the casting house. Installation of cast house slag granulation facilities linking up with lining of blast furnaces have already been proposed in all the integrated steel plants in India as a part of ongoing modernization program to increase the granulation rate. The granulated Blast Furnace Slag presently being utilized by cement factories is not more than 20% of the total slag availability. Hence there is a very wide scope for steel makers to set up to cement factories to utilize all the slag. Steel makers have plans for the utilization of SMS slag for road building and railway ballast. Also it is anticipated that the use of SMS slag as a soil enrichener would increase once the hurdles currently existing regarding the levy of excise duty on the sale of slag for this purpose are . The steel producers are petitioning the Government of India to consider the following incentives for promoting waste Utilisation:

- exemption of sales tax and excise for products made from wastes like slag
- special concessions for plants set up for the Utilisation of wastes
- consessional duty for import of machinery required for the Utilisation of waste.

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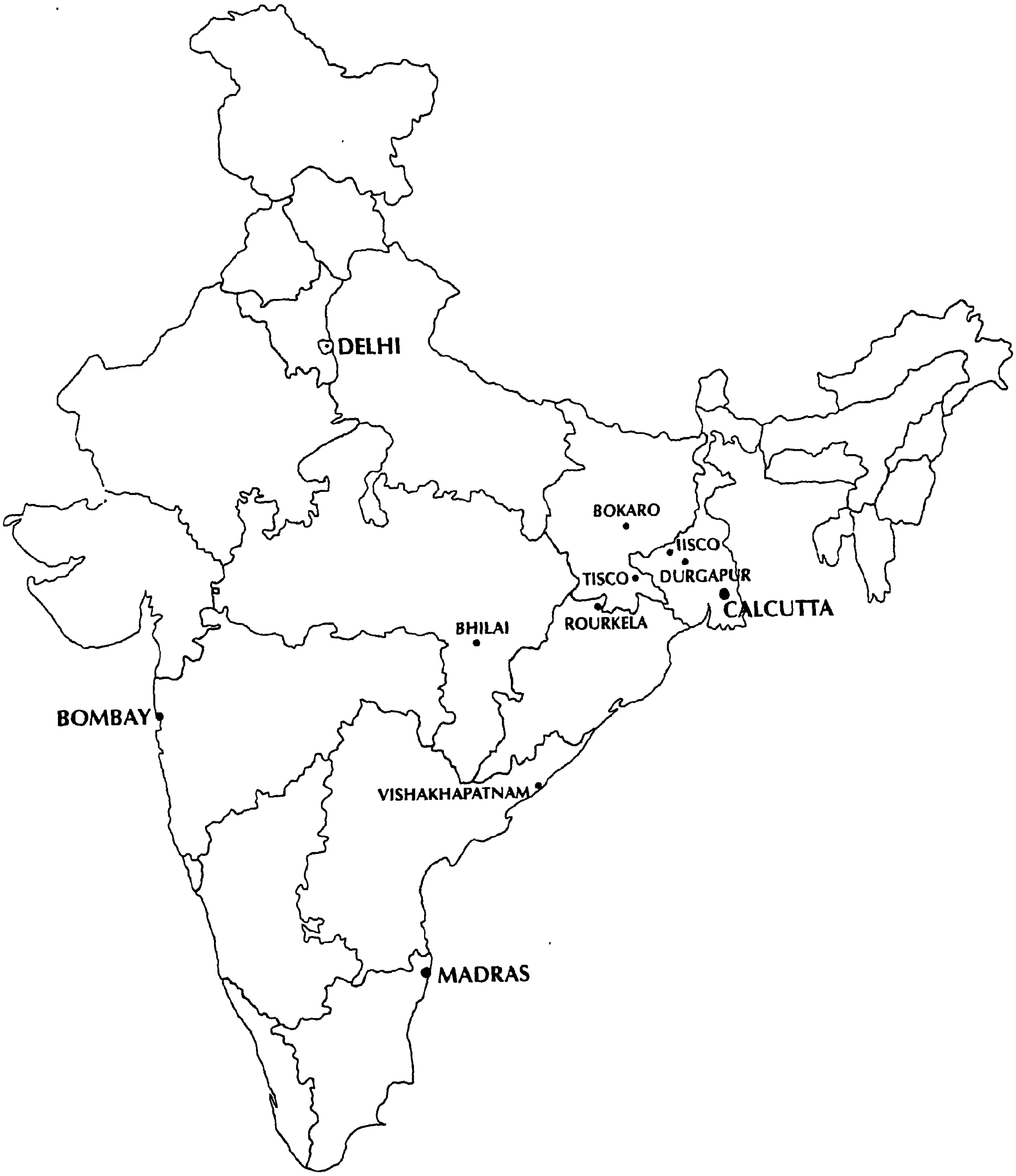
Appendix 1. Location of Integrated Iron and Steel Plant



Appendix 2. Production of iron and steel in India

(million tonne)

Product	Pig iron (including secondary producers)	% change over previous year	Finished steel (incl. secondary producers)	% change over previous year
1985-86	10.03	-	10.02	4
1986-87	10.45	4	10.54	5
1987-88	10.87	3	11.94	11
1988-89	11.66	6	13.36	10
1989-90	11.95	2	13.84	3
1990-91	12.1	1	13.82	-1
1991-92	12.83	5	14.69	6
1992-93	17 54	26	14.89	1
1993-94	-		15.13	1
1994-95	-	-	17.82	15
Annual growth rate	7.23%		5.9%	-

Appendix 3. Production of finished steel

(million tonne)

Plant	1985-86	1986-87	1987-88	1988-89	1989-90	1990-91	1991-92	1992-93	1993-94	1994-95
Bhilai	1.55	1.56	1.64	1.93	1.98	2.06	2.16	2.14	-	-
Bokaro	1.63	1.64	1.86	2.14	2.19	2.33	2.64	2.86	-	-
Durgapur	0.42	0.42	0.42	0.51	0.51	0.53	0.51	0.45	-	-
Rourkela	0.92	0.99	0.99	1.10	1.14	1.09	1.09	1.15	-	-
IISCO	0.36	0.39	0.43	0.35	0.30	0.28	0.34	0.34	-	-
TOTAL SAIL	4.88	5.00	5.34	6.03	6.12	6.29	6.74	6.94	7.13	7.52
VSP	-	-	-	-	-	0.02	0.24	0.54	0.66	1.19
TISCO	0.91	0.82	0.98	1.04	0.93	0.93	0.99	0.94	0.97	1.47
Alloy steel plant	0.06	0.08	0.08	0.1	0.13	0.14	0.16	0.16	-	-
Salem steel plant	0.02	0.02	0.03	0.03	0.03	0.04	0.04	0.03	-	-
Visvesvaraya iron & steel plant	0.05	0.05	0.04	0.04	0.06	0.07	0.09	0.07	-	-
Total main producer	5.9	5.99	6.7	7.31	7.28	7.5	8.30	8.71	8.77	9.57
Secondary producer	4.07	4.54	5.22	6.04	6.56	6.31	6.39	6.18	6.36	8.25
Total finished steel	10.02	10.54	11.94	13.36	13.84	13.82	14.69	14.89	15.13	17.82

Financial Year - 1st April to March 31st.

Source: SAIL 1994, India 1995

Appendix 4. Rank wise company profile for main steel producers in India

Rank	Company	Year	Market capitalisation (Million Rupees)		% share in 1994	Total Sales (Million Rupees)		% share in 1994	Profit Before Tax (Million Rupees)	
			1994	1993		1994	1993		1994	1993
1	Steel Authority of India	FY	244130	153450	58	104770	96110	61	4230	3650
2	Tata Iron & Steel Co	FY	99140	56260	23	37310	32950	22	1800	1190
3	Essar Gujarat	FY	35910	12950	9	7250	4900	4	1800	1230
4	Jindal Iron & Steel Co	FY	13940	2170	3.5	2290	1280	1	330	190
5	Jindal Strips	FY	10040	5540	2	6020	5090	4	500	320
6	Saw Pipes	FY	9390	4910	2	2880	1640	2	470	190
7	Mukand	FY	6190	3380	1.5	6370	7220	4	140	150
8	Special Steels	FY	3510	2530	1	3790	2750	2	50	200
	Total (main producers)		**42227**	**24123**	**100**	**17072**	**15198**	**100**	**935**	**715**

Source: Financial Express, 1995.

Appendix 5. Rank wise company profile for small steel producers in India

Rank	Company	Year	Market capitalisation (Million Rupees)		Total Sales (Million Rupees)		Profit Before Tax (Million Rupees)	
			1994	1993	1994	1993	1994	1993
1	Bhushan Steel & Strips	FH	3040	-	1180	700	140	50
2	Usha Martin Inds	FH	2540	980	1240	1280	70	110
3	Indian Seamless Metal Tube	FH	2400	1710	670	590	50	30
4	Surya Roshni	FH	2170	710	1420	990	50	30
5	Maharashtra Seamless	FH	1560	1240	480	360	20	-7
6	Ipitata Sponge Iron	FH	1540	690	230	200	20	30
7	Panchmahal Steel	FH	1490	-	770	610	40	20
8	Oil Country Tubular	FH	1250	390	470	200	40	-30
9	Bhupendra Industries	FH	1190	-	470	320	40	6
10	Tata Metals & Strips	FH	1110	1010	370	300	30	40
11	Uttam Steels	FH	1080	380	1300	850	90	60
12	Mahindra Ugine Steel Co	FH	990	450	900	810	20	-90
13	Isibars	FH	900	370	140	60	40	10
14	Bellary Steels & Alloys	FH	840	240	420	240	40	6
15	Revathi-CP Equipment	FH	800	420	130	130	20	20
16	National Steel Inds	FH	680	580	1040	800	60	40
17	Mukat Pipes	FH	660	460	140	70	20	10
18	N S L	FH	630	320	940	660	20	20
19	Zenith	FH	590	250	900	840	-110	-150
20	Bihar Sponge Iron	FH	550	410	450	280	-10	-120
21	Electrosteel Castings	FH	530	350	760	450	40	20
22	Choksi Tube Co	FH	500	290	200	150	20	10
23	Grand Foundry	FH	460	370	260	70	40	20
24	Shree Precoated Steels	FH	420	-	90	00	8	-
25	East Coast Steel	FH	400	140	460	290	50	3

Rank	Company	Year	Market capitalisation (Million Rupees)		Total Sales (Million Rupees)		Profit Before Tax (Million Rupees)	
			1994	1993	1994	1993	1994	1993
26	Rathi Alloys & Steel	FH	330	290	420	420	-60	-20
27	Viraj Alloys	FH	330	-	300	130	10	5
28	Steel Tubes of India	FH	330	140	710	500	10	10
29	Kusum Ingots & Alloys	FH	320	220	300	280	10	10
30	Denholm Steels	FH	300	-	270	20	20	1
31	Marmagoa Steels	FH	290	60	130	100	-50	-50
32	Thapar Ispat	FH	280	100	270	180	30	20
33	STI Biplus Tubing (India)	FH	280	120	90	50	20	10
34	Singhal Swaroop Ispat	FH	250	70	350	240	10	10
35	Kanishk Steel Inds	FH	240	-	170	110	10	5
36	Ensa Steel Inds	FH	220	90	360	270	30	20
37	Metalman Pipe Mfg Co	FH	220	280	420	240	30	20
38	G K Steel & Allied Inds	FH	210	70	320	400	10	1
39	Bhuwalka Steel Inds	FH	210	40	430	360	10	5
40	Nova Steels (India)	FH	210	250	300	440	10	10
41	Surana Strips	FH	210	90	180	140	8	4
42	Siddartha Tubes	FH	180	100	250	170	10	9
43	Gandhi Special 07 Tubes	FH	170	60	90	70	5	-1
44	Graham Firth Steel Product	FH	140	40	310	210	6	-0
45	Sujana Steels	FH	140	-	220	130	10	7
46	Shree Steel Wire Ropes	FH	140	-	60	20	10	1
47	Tamilnadu Steel Tubes	FH	140	-	190	110	10	2
	Total (other producers)		**3366**	**1394**	**2178**	**1606**	-	-

FH-First half (1st April to September end)

Source: Financial Express, 1995.

Appendix 6. Demand and availability of steel products and finished steel

(million tonne)

Category	Domestic Availability				Total Domestic Availability	Demand 1994-95	% availability over demand	1999-00	2004-05
	SAIL	VSP	TISCO	Secondary					
Bars & rods	0.95	1.19	0.82	5.78	8.74	7.60	115	10.25	13.82
Structurals	0.82	0.97	0.10	1.28	3.18	2.65	120	3.32	4.16
Rly.materials	0.62	-	0.02	0.10	0.75	0.81	92	0.86	0.91
Sub-total	2.41	2.16	0.94	7.17	12.68	11.06	115	14.45	18.90
Plates	1.91	-	0.18	0.05	2.14	2.02	105	2.73	3.69
HRC/SK/SH	1.29	-	1.04	1.00	3.34	3.45	96	4.82	6.75
CR coils	1.53	-	-	0.80	2.33	2.00	115	2.90	4.20
GP/GC sheets	0.32	-	44	0.30	0.66	0.64	103	0.93	1.35
Elect. sheets	0.07	-	60	0.01	0.14	0.25	59	0.36	0.52
Tin plates	0.08	-	-	0.15	0.23	0.35	65	0.40	0.46
Pipes	0.10	-	-	0.09	0.19	0.30	63	0.45	0.67
Sub-total	5.32	-	1.33	2.40	9.05	9.01	225	12.59	17 65
Total finished steels	7.73	2.16	2.27	9.58	21.73	20.07	108	27.02	36 55

Source: CIER' Industrial Data Book, 1994.